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Original article

Knowledge, attitude, and perception regarding bioinformatics among healthcare students of Jouf University, Saudi Arabia: A cross-sectional study

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Running Title :KAP of bioinformatics among healthcare students

Keywords: Bioinformatics, healthcare, Saudi Arabia

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Abstract

Background: Bioinformatics is an essential interdisciplinary field that integrates computer science, statistics, and biology. Understanding its relevance is crucial for healthcare students to enhance patient care and research.

Objective: This study assessed the knowledge, attitudes, and perceptions regarding bioinformatics among healthcare students at Jouf University, Saudi Arabia.

Methods: A cross-sectional survey was conducted among students at four different colleges (medical, dental, applied medical science, and pharmacy) of a public university. The study was undertaken between February 2024 and May 2024. Data were collected through a structured questionnaire. Descriptive statistics were performed for demographic variables and questionnaire responses. Normality of the data was assessed using the Shapiro–Wilk test. Since the data were non-normally distributed, the Mann–Whitney U test and Kruskal–Wallis test were used for inferential analysis.

Results: A total of 248 participants were included in the study. The mean age of participants was 23.02 years, with an almost equal gender distribution (48.8% male, 51.2% female). A majority of students exhibited a positive attitude towards bioinformatics, with 62.9% to 79.8% answering affirmatively to knowledge-related questions. Male students demonstrated significantly higher median knowledge scores compared to female students ($p = 0.011$). Although first-year students demonstrated comparatively lower knowledge scores than senior students, the association between academic year and knowledge scores was not statistically significant. No significant associations were observed between attitude or perception scores and demographic variables.

Conclusion: The study highlights a gender disparity in knowledge regarding bioinformatics among healthcare students, with a need for targeted educational interventions, particularly for female students and first-year cohorts. Enhancing the curriculum could improve the understanding and application of bioinformatics in healthcare settings.

Keywords: Bioinformatics, healthcare, Saudi Arabia

Introduction

The term ‘Bioinformatics’ was coined by Paulien Hogeweg and Ben Hesper in 1970 as the study of informatics processes in biotic systems. It encompasses the computational management and analysis of biological information, including genes, genomes, proteins, cells,

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ecological systems, medical data, robots, and artificial intelligence.[1] Advancements in bioinformatics have fundamentally reshaped the landscape of healthcare, creating new pathways for diagnosis and treatment. By leveraging large-scale biological data, including genomic and proteomic information, bioinformatics facilitates personalized medicine, allowing healthcare professionals to tailor treatments based on individual genetic profiles.[2] Furthermore, bioinformatics aids in understanding complex disease mechanisms by identifying biomarkers and enhancing predictive modelling of disease progression. As in many scientific domains, bioinformatics has emerged alongside advancements in computing tools and environments, enabling researchers to share data more efficiently.[3,4]

The shortage of bioinformatics expertise is a global challenge.[5] In Saudi Arabia, a recent survey involving 179 scientists revealed critical insights into the state of bioinformatics knowledge and usage. The survey found that 93% of respondents acknowledged the essential role of bioinformatics tools in modern research. Despite this awareness, only 53% reported receiving bioinformatics training during their formal education, and just 11% received on-the-job training. Furthermore, 48% of the surveyed scientists were actively engaged in areas such as gene expression analysis, protein expression analysis, and mutation analysis, illustrating a demand for more widespread and in-depth training programs.[6] To address these challenges and align with national development goals, Saudi Arabia established the Saudi Data & Artificial Intelligence Authority (SDAIA) in August 2019 through a Royal Decree. SDAIA plays a pivotal role in facilitating the country's transformation into a data-driven economy, a key component of Vision 2030. By unifying national efforts and launching strategic initiatives related to data and AI, SDAIA aims to position the Kingdom as a global leader in data science and artificial intelligence.[7] This ambitious agenda emphasizes the optimal utilization of resources and the cultivation of a highly skilled workforce to drive innovation and economic growth in the field of bioinformatics and beyond.[8]

As healthcare continues to embrace these technologies, the need for healthcare students to develop competencies in bioinformatics becomes increasingly apparent, highlighting its importance in modern medical curricula. Assessing students' current level of understanding and perceptions is therefore important for guiding curriculum development and future educational interventions. Ultimately, the incorporation of bioinformatics into healthcare practices not only streamlines patient care but also fosters a more detailed understanding of disease and treatment options in a rapidly evolving field.[9] A recent cross-sectional study by Alomair L and Abolfotouh MA revealed that many participants in Saudi Arabia possess limited

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knowledge, a neutral attitude, and insufficient resources related to bioinformatics in genomics research.[10] Similarly, research by Elghriani A et al. highlighted a lack of bioinformatics knowledge among healthcare professionals.[11]

Despite the increasing importance of bioinformatics in healthcare education and clinical practice, limited evidence exists regarding the preparedness, awareness, attitudes, and perceptions of healthcare students in Saudi Arabia, particularly across different academic levels and healthcare disciplines. Moreover, data from northern Saudi Arabia remain scarce. Identifying these gaps is essential for developing targeted educational strategies and curriculum reforms aimed at improving bioinformatics competency among future healthcare professionals.

The primary aim of this study was to assess their knowledge, attitudes, and perceptions regarding bioinformatics, along with identifying socio-demographic predictors influencing their understanding of the subject.

We hypothesized that knowledge regarding bioinformatics would significantly differ according to socio-demographic characteristics such as gender, academic year, and healthcare discipline.

Materials and Methods

Study design

A cross-sectional study was used with data collected between February 2024 and May 2024. Ethical approval was obtained from the Local Committee of Bioethics, Jouf University (Approval No. 1-02-45). All procedures were conducted in accordance with the Declaration of Helsinki.

Sample population, size and characteristics

Sample size estimation was completed using GPower software (version 3.0). Sample size was estimated for the chi-square test and goodness-of-fit test: Contingency tables were chosen. A minimum total sample size of 248 (62 per group) was found to be sufficient for an alpha of 0.05, power of 80%, 0.21 as effect size (based on differences in awareness of the purpose of bioinformatics, assessed from the study by Elghriani A et al.),[11] and 3 degrees of freedom. The sample size formula used was:

$$N = [(Z\alpha/2 + Z\beta)^2 \times p(1-p)] / d^2$$

Where:

- N = required sample size
- Zα/2 = standard normal deviate at 95% confidence interval

- Zβ = standard normal deviate corresponding to 80% power
- p = expected proportion
- d = margin of error

We targeted a sample of 248 students from different healthcare colleges (College of Medicine, College of Dentistry, College of Applied Medical Sciences, and College of Pharmacy) at Jouf University, Saudi Arabia, which is one of the leading public universities in the northern region. Participants who met the inclusion criteria for participation were chosen using non-probability convenience sampling. Eligible students who were available during the data collection period were approached consecutively in classrooms and clinics to minimize selection bias. The inclusion criteria comprised Saudi students enrolled in regular bachelor's programs at the university. Students unwilling to participate were excluded.

Data collection and survey tool

A well-structured, self-designed, anonymous, and pre-tested questionnaire was administered to all the selected students (1st to 5th academic years and interns). The overall questionnaire consists of sixteen questions. The questionnaire included the following four sections-

(1) Section I collected information about participants' characteristics such as age, gender, college name, and academic year - Questions 1-4;

(2) Section II comprised questions focused on knowledge of bioinformatics - Questions 5-12;

(3) Section III addressed attitudes towards bioinformatics - Questions 13 and 14; and

(4) Section IV explored participants' perceptions of bioinformatics - Questions 15 and 16.

All statements regarding knowledge, attitude, and perception included three response options: "yes," "not sure," and "no." However, the first knowledge statement, which asked participants, "Have you ever heard of the term 'Bioinformatics'?" provided only two options: "yes" and "no."

The questionnaire was hand-delivered by the 1st and 2nd authors to all the students (male and female) (based on their curriculum and availability within the college) and was collected on the same day. The students were invited to participate in the study from the classroom and/or clinics. Participation was voluntary, and the purpose of the survey was briefed to them before obtaining informed consent. They were assured at the beginning of the questionnaire that the results of the survey would only be presented or published as aggregate data, maintaining the confidentiality of personal information.

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Reliability of questionnaire

Content validity of the questionnaire was evaluated by a panel of three experts in healthcare education and bioinformatics, who assessed the relevance, clarity, and comprehensiveness of the items. Minor modifications were made based on their feedback prior to pilot testing. The questionnaire was piloted on 10 fifth-year dental students to ensure clarity, practicability of the questions, and ease of completion. The reliability of the questionnaire was assessed based on findings of this pilot study. Cronbach's alpha was used as a measure of reliability (0.91).

Statistical analysis

Statistical analysis was conducted using the Statistical Package for Social Sciences version 20.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics for age were summarized using mean and standard deviation, while categorical variables were presented as frequencies and percentages. Normality of knowledge, attitude, and perception scores was assessed using the Shapiro–Wilk test. Since the data were not normally distributed ($p < 0.05$), non-parametric tests were used. The Mann–Whitney U test was used for comparisons between two groups, while the Kruskal–Wallis test was used for comparisons among more than two groups. Statistical significance was set at $p \leq 0.05$.

Results

Baseline characteristics of participants

The study included a total of 248 healthcare students from Jouf University, with a mean age of 23.02 years (SD = 2.02, range 20-30). The gender distribution was almost equal, with 121 males (48.8%) and 127 females (51.2%). The participants were evenly distributed across various colleges (N = 62 per college). The academic year distribution included first-year (10.9%), second-year (13.3%), third-year (12.5%), fourth-year (11.3%), fifth-year (14.5%), and interns (37.5%). **Table 1** presents the demographic characteristics of the participants.

Knowledge, attitude, and perception scores demonstrated non-normal distribution on Shapiro–Wilk testing ($p < 0.05$); therefore, non-parametric tests were used for inferential analysis.

Knowledge, attitude and perception regarding bioinformatics

In terms of knowledge of bioinformatics, 62.9% (N = 156 students) of participants had awareness about this field. A significant majority (N = 184, 74.2%) understood bioinformatics as an interdisciplinary field, and 70.2% (N = 174) recognized its applications in addressing

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biological problems. Additionally, 54.8% (N = 136) noted its extensive applications, including gene therapy and personalized medicine. Notably, 79.0% (N = 196) recognized that bioinformatics plays a crucial role in genetics and the treatment of genetic diseases.

The attitudes of participants towards bioinformatics were generally positive, with 62.9% (N = 156) believing that bioinformatics information could be beneficial for employers and insurers. Additionally, 74.2% (N = 184) expressed concern about the potential misuse of bioinformatics information as a "bioweapon."

Concerning perceptions of bioinformatics, a significant majority of participants demonstrated a strong interest in bioinformatics education, with 58.9% (N = 146) expressing a desire to attend courses or seminars related to the field. Furthermore, 79.8% (N = 198) believed that bioinformatics should be incorporated into their curriculum.

Table 2 summarizes responses to knowledge, attitude, and perception-related statements about bioinformatics

Knowledge scores by demographic variables

Table 3 presents the comparison of knowledge scores according to demographic variables. Male students demonstrated significantly higher median knowledge scores than female students ($p = 0.011$). Although first-year students demonstrated comparatively lower median knowledge scores than senior students and interns, the association between academic year and knowledge scores was not statistically significant ($p = 0.164$). Similarly, no statistically significant association was observed between college type and knowledge scores ($p = 0.121$). Although variations in median knowledge scores were observed across academic years, the overall Kruskal–Wallis test was not statistically significant ($p = 0.164$); therefore, Bonferroni-adjusted post hoc pairwise comparisons were not performed.

Attitude scores by demographic variables

Table 4 presents the comparison of attitude scores according to demographic variables. No statistically significant association was observed between attitude scores and gender ($p = 0.774$), college type ($p = 0.307$), or academic year ($p = 0.307$). Overall, participants demonstrated similar attitude scores across all demographic categories.

Perception scores by demographic variables

Table 5 presents the comparison of perception scores according to demographic variables. No statistically significant association was observed between perception scores and gender ($p = 0.749$), college type ($p = 0.290$), or academic year ($p = 0.290$). Participants across different demographic groups demonstrated comparable perception scores regarding bioinformatics.

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Discussion

The current study was conducted to evaluate healthcare professionals' awareness and perceptions of bioinformatics, focusing on their understanding of its importance and applications in modern healthcare. This is particularly important because with the increasing relevance of bioinformatics to clinical practice, research, and healthcare data management, the determination of the extent of familiarity with this interdisciplinary field by students in the healthcare professions becomes useful for shaping future curricula.

In the current study, 62.9% of students demonstrated knowledge regarding bioinformatics. This is in accordance with the previous studies, in which a trend to increase familiarity regarding bioinformatics was observed among the healthcare students. While 74.2% of the respondents recognized that bioinformatics is a science that integrates biology, computer science, and mathematics, fewer participants recognized the application of bioinformatics in areas such as gene therapy, personalized medicine, and preventive medicine. This discrepancy indicates that although bioinformatics is valued as an interdisciplinary science, there still appears to be a widespread misunderstanding regarding the practical value of bioinformatics in solving biological and medical problems.[12,13] According to Alomair L and Abolfotouh MA, even Saudi scientists had certain lapses in knowledge with regard to using bioinformatics tools properly in interpreting genomic data.[10] Similarly, Beckmann JS and Lew D found that although bioinformatics facilitates precision medicine, limited education remains a key barrier to its full implementation in clinical practice.[14] Thus, it is imperative to cultivate a more robust educational framework that emphasizes experiential learning and interdisciplinary collaboration to enhance students' competencies in bioinformatics.

In the current study, gender demonstrated a significant association with knowledge regarding bioinformatics, with male students exhibiting higher median knowledge scores compared to female students. Although first-year students demonstrated comparatively lower scores than senior students and interns, the association between academic year and knowledge scores was not statistically significant. The observed gender disparity calls for interventions targeting this imbalance. Botella C et al. explored a set of cultural and structural barriers that deter and discourage female students from engaging with the subjects of science, technology, engineering, and mathematics due to limited role models and lack of opportunities for mentorship.[15] Similarly, Barrett AA et al. emphasized how the creation of gender-sensitive learning environments serves as a motivating factor for females towards further involvement in bioinformatics education.[16] Cline S also found that strategies targeting the encouragement

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of female students to take up bioinformatics would be essential to increasing their confidence in the subject.[17] Addressing these disparities requires a multifaceted approach that deals with gender-inclusive teaching methodologies, mentorship programs for female students, and the development of a nurturing learning environment to facilitate the increasing participation of females in these fields.

In our study, fifth-year students and interns demonstrated comparatively higher knowledge levels than students in earlier academic years, although the association was not statistically significant. First-year students demonstrated the lowest median knowledge scores, suggesting limited early exposure to bioinformatics concepts. Previous studies have similarly reported that early integration of bioinformatics education improves students' confidence and competency in applying bioinformatics tools during later stages of healthcare education.[18,19] Several authors have therefore recommended introducing bioinformatics concepts early within undergraduate healthcare curricula and integrating them with subjects such as molecular biology and genetics.[20-24]

In the present study, no statistically significant association was observed between demographic characteristics and attitude or perception scores regarding bioinformatics. Participants across different genders, academic years, and healthcare disciplines demonstrated relatively similar attitudes and perceptions toward bioinformatics education and applications. This finding suggests that awareness regarding the importance and ethical implications of bioinformatics may be uniformly distributed among healthcare students irrespective of their demographic background. Similar observations have been reported in previous studies, where students generally demonstrated positive attitudes toward bioinformatics despite differences in educational exposure and academic levels.[25-28] The uniformly favorable perception regarding the inclusion of bioinformatics in healthcare curricula may reflect the growing recognition of its importance in modern healthcare, precision medicine, and biomedical research.

Our study findings also indicated a strong need for bioinformatics education: 79.8% of students suggested including bioinformatics in the curriculum for medical and dental studies. Additionally, 58.9% of the respondents reported that they would wish to attend bioinformatics courses or seminars, reflecting growing student interest in this field. According to Alomair L and Abolfotouh MA, two-thirds of participants in their study emphasized the need for a dedicated bioinformatics degree, though biology or IT degrees combined with training were seen as viable alternatives. Life sciences, particularly biology, were ranked highest for a career in bioinformatics, followed by medicine and computer science.[10] Similarly, Williams JJ et al.

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conducted a nationwide survey of 1,260 U.S. faculty teaching bioinformatics to undergraduate biology students. The main barriers identified were lack of faculty expertise, student interest, curriculum space, and student preparation.[29] Considering the growing role of bioinformatics in clinical practice and medical research, formal training should be incorporated into healthcare education. While many countries primarily offer bioinformatics at the graduate level, undergraduate integration remains limited due to insufficient training, instruction, and student interest.[10]

The present findings indicate that although bioinformatics is gradually being integrated into healthcare education, gender differences in knowledge levels still exist among healthcare students. Other predictors should be explored in future studies, including prior exposure to computational sciences or individual interest in research, which could also affect knowledge levels.

Limitations

The study had several limitations that should be considered. First, it focused solely on healthcare university students, which may not have accurately reflected the broader knowledge and attitudes toward bioinformatics in the general Saudi population. Additionally, conducting research at only one university limited the generalizability of the findings to other healthcare students in Saudi Arabia, where educational experiences may have differed. Reliance on self-reported data introduced the potential for bias, as participants may have overestimated their knowledge. The use of convenience sampling may have introduced selection bias and limited the representativeness of the study population. Lastly, the cross-sectional design captured data at a single point in time, restricting the ability to assess changes in knowledge and attitudes or establish causal relationships.

Conclusion

The results demonstrate a general awareness and positive attitude towards bioinformatics among healthcare students at Jouf University, though knowledge levels varied significantly according to gender. The findings highlight the need for improved educational strategies to enhance knowledge and the integration of bioinformatics in healthcare curricula. Future multicenter studies involving larger and more diverse populations are recommended to further validate these findings and evaluate the impact of educational interventions.

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Early Uncorrected

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Early Version - Uncorrected

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TABLES

Table 1. Demographic distribution of study participants (N = 248)

Variables	Frequency (n)	Percentage (%)
Age (in years)		
Mean ± S.D. = 23.0 ± 2.0	--	--
Range = 20-30	--	--
Gender		
Male	121	48.8%
Female	127	51.2%
College		
Medical	62	25.0%
Dental	62	25.0%
Applied Medical Sciences	62	25.0%
Pharmacy	62	25.0%
Academic year		
First	27	10.9%
Second	33	13.3%
Third	31	12.5%
Fourth	28	11.3%
Fifth	36	14.5%
Intern	93	37.5%

Table 2. Knowledge, attitudes, and perceptions of bioinformatics among participants

Statement	No		Not sure		Yes	
	N	%	N	%	N	%
Knowledge						
Have you ever heard of the term "Bioinformatics"	92	37.1%	-	-	156	62.9%
Bioinformatics is an interdisciplinary area of science composed of biology, mathematics, and computer science	2	0.8%	62	25.0%	184	74.2%
Bioinformatics aims to solve biological problems using DNA and amino acid	16	6.5%	58	23.4%	174	70.2%

Early Version - Uncorrected

Statement	No		Not sure		Yes	
	N	%	N	%	N	%
sequences and related information						
Bioinformatics deals with storage, retrieval, analysis, and interpretation of biological data using computer-based software and tools	18	7.3%	50	20.2%	180	72.6%
The objectives of bioinformatics include the development of databases for efficient storage, access, and management of the large body of various biological information	26	10.5%	66	26.6%	156	62.9%
The objectives of bioinformatics include the application of these tools for the analysis and interpretation of the various biological data	18	7.3%	48	19.4%	182	73.4%
Bioinformatics has vast applications, such as gene therapy, personalized medicine, and preventive medicine.	20	8.1%	92	37.1%	136	54.8%
I am glad that bioinformatics has provided useful knowledge regarding genetics that can help in treating many serious genetic diseases	6	2.4%	46	18.5%	196	79.0%
Attitude						
I believe that information related to bioinformatics could be	10	4.0%	82	33.1%	156	62.9%

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Statement	No		Not sure		Yes	
	N	%	N	%	N	%
exploited by employers, insurance companies, etc.						
I believe that information related to bioinformatics could be used as a “bioweapon”	16	6.5%	48	19.4%	184	74.2%
Perception						
I would be interested in attending courses and/or educational seminars related to bioinformatics	14	5.6%	88	35.5%	146	58.9%
Bioinformatics should be included as a part of medical/dental curriculum	14	5.6%	36	14.5%	198	79.8%

Table 3. Comparison of knowledge scores across demographic variables

Variables	Category	N	Median (IQR)	Test statistic	p-value
Gender	Male	121	5.0 (4.0–7.0)	Mann–Whitney U = 516.0	0.011*
	Female	127	4.0 (2.0–6.0)		
College	Medical	62	4.0 (3.0–6.0)	Kruskal–Wallis H = 5.82	0.121
	Dental	62	5.0 (3.0–7.0)		
	Applied Medical Sciences	62	4.0 (2.0–6.0)		
	Pharmacy	62	5.0 (3.0–7.0)		
Academic year	First	27	2.0 (1.0–4.0)	Kruskal–Wallis H = 9.17	0.164
	Second	33	5.0		

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Variables	Category	N	Median (IQR)	Test statistic	p-value
			(3.0–6.0)		
	Third	31	5.0 (3.0–7.0)		
	Fourth	28	5.0 (4.0–6.0)		
	Fifth	36	5.0 (4.0–7.0)		
	Intern	93	5.0 (4.0–7.0)		

**Statistically significant*

Table 4. Comparison of attitude scores across demographic variables

Variables	Category	N	Median (IQR)	Test statistic	p-value
Gender	Male	121	2.0 (1.0–2.0)	Mann–Whitney U = 352.5	0.774
	Female	127	2.0 (1.0–2.0)		
College	Medical	62	2.0 (1.0–2.0)	Kruskal–Wallis H = 7.16	0.307
	Dental	62	2.0 (1.0–2.0)		
	Applied Medical Sciences	62	2.0 (1.0–2.0)		
	Pharmacy	62	2.0 (1.0–2.0)		
Academic year	First	27	1.0 (1.0–2.0)	Kruskal–Wallis H = 7.16	0.307
	Second	33	2.0 (1.0–2.0)		
	Third	31	2.0 (1.0–2.0)		
	Fourth	28	2.0 (1.0–2.0)		
	Fifth	36	2.0 (1.0–2.0)		
	Intern	93	2.0		

Early Version - Uncorrected

Variables	Category	N	Median (IQR)	Test statistic	p-value
			(1.0–2.0)		

Table 5. Comparison of perception scores across demographic variables

Variables	Category	N	Median (IQR)	Test statistic	p-value
Gender	Male	121	2.0 (1.0–2.0)	Mann–Whitney U = 383.5	0.749
	Female	127	2.0 (1.0–2.0)		
College	Medical	62	2.0 (1.0–2.0)	Kruskal–Wallis H = 7.34	0.290
	Dental	62	2.0 (1.0–2.0)		
	Applied Medical Sciences	62	2.0 (1.0–2.0)		
	Pharmacy	62	2.0 (1.0–2.0)		
Academic year	First	27	1.0 (1.0–2.0)	Kruskal–Wallis H = 7.34	0.290
	Second	33	2.0 (1.0–2.0)		
	Third	31	2.0 (1.0–2.0)		
	Fourth	28	2.0 (1.0–2.0)		
	Fifth	36	2.0 (1.0–2.0)		
	Intern	93	2.0 (1.0–2.0)		

Early Version - Uncorrected